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Remarks

Claim 1-7 and 9-14 have been amended. Claims 8, 15, and 16 have been cancelled. Claims 17-23 have been added. New independent Claim 17 includes limitations originally presented in Claims 1 and 9, and new dependent Claims 18-23 include limitations originally presented in Claims 2 and 10-14. Therefore no new matter is introduced by the present Amendment. Applicant and his representatives wish to thank Examiner Nguyen for the thorough examination of the present application and the detailed explanations in the Office Action dated June 29, 2005.

In one aspect, the present invention relates to a method of manufacturing silicide, including the steps of (a) cleaning a semiconductor substrate with a transistor formed thereon, (b) placing the cleaned semiconductor substrate into a sputter chamber in a deposition equipment, and forming silicide while depositing a metal film and heating the semiconductor substrate at a temperature of from greater than 450 to 600°C (so-called "in situ" silicide formation), (c) removing residual metal film not used for the formation of silicide, and (d) annealing the semiconductor substrate. (See Claim 1 as amended, above.) The cited references do not disclose or suggest depositing a metal film while heating the semiconductor substrate at a temperature of greater than 450°C.

In another aspect (new Claim 17, originally presented in substantial part in original Claim 9), the metal in step (b) is sputtered at a DC power of 2 ~ 10kW, while heating the semiconductor substrate at a temperature of 450 to 600°C. The cited references do not disclose or suggest any DC power at all for the metal sputtering step. Therefore claim 17 is fully patentable over the cited references.

The Rejection of Claims 1-2, 8-9, and 12-14 under 35 U.S.C. § 103(a)

The rejection of Claims 1-2, 8-9, and 12-14 under 35 U.S.C. § 103(a) as being unpatentable over Hamanaka (US 6,337,272) is respectfully traversed.

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Hamanaka relates to a method of manufacturing silicide, including the steps of forming a transistor on a substrate (see, e.g., Hamanaka, col. 11, ll. 57-61), removing a native oxide film from the surface of the substrate (see, e.g., Hamanaka, col. 12, ll. 7-10), placing the semiconductor substrate in a sputtering apparatus (see, e.g., Hamanaka, col. 12, ll. 10-12), forming silicide while sputtering metal and heating the substrate (see, e.g., Hamanaka, col. 12, ll. 12-26), removing the unreacted and partially oxidized metal (see, e.g., Hamanaka, col. 12, ll. 62-66), and performing an annealing process (see, e.g., Hamanaka, col. 12, ll. 66-67).

Hamanaka discloses heating the semiconductor substrate, while depositing metal, at temperatures of 200°C (col. 12, ll. 13-15), 450°C (col. 8, ll. 43-48), or between 300°C and 400°C (col. 12, ll. 38-43). Hamanaka fails to disclose or suggest depositing a metal film while the semiconductor substrate is heated at a temperature of from greater than 450°C to 600°C. Thus, Hamanaka does not disclose or suggest all of the limitations of Claim 1 of the present application, and the claimed ranges do not overlap or lie inside ranges disclosed by Hamanaka. Therefore, the rejection of Claim 1 and dependent claims 2, 9, and 12-14 under 35 U.S.C. § 103(a) as being unpatentable over Hamanaka should be withdrawn.

The Rejection of Claims 3-4 under 35 U.S.C. § 103(a)

The rejection of Claims 3-4 under 35 U.S.C. § 103(a) as being unpatentable over Hamanaka in view of O'Brien (US 6,458,711) is respectfully traversed.

O'Brien relates to a method of forming silicide, including the steps of sputtering metal onto a substrate, and, in a separate step, inserting the coated substrate into a nitrogen atmosphere and raising the temperature to 600°C to create silicide. (See, e.g., O'Brien, col. 2, ll. 54-62.) O'Brien further discloses stripping residual metal (i.e., metal not used for the formation of silicide) with an SC1 solution. (See, e.g., O'Brien, col. 3, ll. 40-55.) We note, for the record, that the SC1 solution disclosed by O'Brien has a different composition ratio than the SC1 solution disclosed by the present specification, but do not rely on that discrepancy for the remainder of this argument.

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O'Brien forms silicide by heating the substrate to 600°C *after* sputtering metal onto the substrate. Therefore, O'Brien fails to cure Hamanaka's deficiency with respect to depositing a metal film *while* the semiconductor substrate is heated at a temperature of from greater than 450°C to 600°C. Thus, the combination of Hamanaka and O'Brien does not disclose or suggest all of the limitations of Claim 1 of the present application. Therefore, the rejection of dependent Claims 3-4 under 35 U.S.C. § 103(a) as being unpatentable over Hamanaka in view of O'Brien should be withdrawn.

The Rejection of Claims 5-7 under 35 U.S.C. § 103(a)

The rejection of Claims 5-7 under 35 U.S.C. § 103(a) as being unpatentable over Hamanaka in view of Sumi (US 6,022,805) is respectfully traversed.

Sumi relates to a method for removing native oxide on a silicide layer after the formation of the silicide. (See, e.g., Sumi, col. 3, ll. 54-61.) Sumi teaches that the silicide is formed by the conventional method of heating the substrate to 600°C *after* sputtering the metal. (See, e.g., Sumi, cols. 1-2, ll. 65-2.) Therefore, Sumi fails to cure Hamanaka's deficiency with respect to depositing a metal film *while* the semiconductor substrate is heated at a temperature of from greater than 450°C to 600°C. Thus, the combination of Hamanaka and Sumi does not disclose or suggest all of the limitations of Claim 1 of the present application. Therefore, the rejection of dependent Claims 5-7 under 35 U.S.C. § 103(a) as being unpatentable over Hamanaka in view of Sumi should be withdrawn.

The Rejection of Claim 11 under 35 U.S.C. § 103(a)

The rejection of Claim 11 under 35 U.S.C. § 103(a) as being unpatentable over Hamanaka in view of Wake (US 6,725,119) should be withdrawn.

Wake relates to a process for designing a cleaning apparatus line configuration in a process for manufacturing a semiconductor device (see, e.g., Wake, col. 7, ll. 30-32), including an apparatus for cleaning semiconductors comprising silicide (see, e.g., Wake, col. 9, ll. 16-18).

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Wake teaches that the silicide is formed by the conventional method of heating the substrate to after sputtering the metal (see, e.g., Wake, Background, col. 3, ll. 25-30). Therefore, Wake fails to cure Hamanaka's deficiency with respect to depositing a metal film *while* the semiconductor substrate is heated at a temperature of from greater than 450°C to 600°C. Thus, the combination of Hamanaka and Wake does not disclose or suggest all of the limitations of Claim 1 of the present application. Therefore, the rejection of dependent Claim 11 under 35 U.S.C. § 103(a) as being unpatentable over Hamanaka in view of Wake should be withdrawn.

New Claims 17-23

New Claim 17 includes limitations originally presented in substantial part in original Claim 9. Claim 17 recites that the metal in step (b) is sputtered at a DC power of 2 – 10kW, while heating the semiconductor substrate at a temperature of 450 to 600°C. Metal sputtered with high power may penetrate a barrier so that silicide can be formed (see, e.g., page 6, paragraph 36, lines 10-14 of the present specification). Hamanaka, O'Brien, and Wake are silent with respect to sputtering power level. Thus any combination of Hamanaka, O'Brien, and/or Wake fails to disclose the limitations of Claim 17. Therefore independent Claim 17 and dependent Claims 18-23 are patentable over Hamanaka in view of O'Brien and/or Wake.

Sumi discloses sputtering metal at various RF power levels (see, e.g., barrier layer 14 made from Ti and an Al based metal layer 15 formed by sputtering, Sumi, col. 11, ll. 2-9). Sumi does not disclose any DC power levels for sputtering, nor does Sumi disclose or suggest any power levels for sputtering metal for forming a silicide. Thus the combination of Hamanaka with Sumi does not disclose sputtering metal at a DC power of 2 – 10kW, while heating the semiconductor substrate at a temperature of 450 to 600°C. Therefore independent Claim 17 and dependent Claims 18-23 are patentable over Hamanaka in view of Sumi.

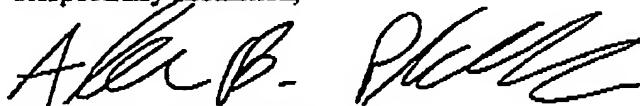
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Conclusions

In view of the above amendments and remarks, all bases for objection and rejection are overcome, and the application is in condition for allowance. Early notice to that effect is earnestly requested.

If it is deemed helpful or beneficial to the efficient prosecution of the present application, the Examiner is invited to contact Applicant's undersigned representative by telephone.

Respectfully submitted,



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